



INFLUENCE OF MONENSIN
ON FEED EFFICIENCY
AND
PUBERTY OF BEEF HEIFERS

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Influence of Monensin on Feed Efficiency and Puberty of Beef Heifers

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Summary

To examine the influence of the feed additive monensin on feed efficiency and the occurrence of puberty in beef heifers, a study was conducted in 1978 and 1979 in which heifers were fed either a control ration, the control ration with the addition of monensin, or a ration formulated to provide a 10 percent greater weight gain than the control ration. Puberty was determined by the presence of a palpable corpus luteum on the ovary or by the expression of visual signs of estrus. During the second year of the study a synthetic progestogen was used to induce puberty and the influence of the diet on the proportion of heifers responding to the induction of puberty was determined. Results of these studies indicated neither age nor weight at puberty was influenced by the addition of monensin to the rations. In addition, no changes due to monensin in measurements related to puberty such as ovary size or concentration of plasma glucose were observed. The heifers with monensin added to their feed required approximately 10 percent less feed per pound of gain than the control cattle and this alone would justify its use in developing replacement heifers.

Introduction

The time of occurrence of puberty in beef heifers is important because it culminates in the ability to reproduce. It is desirable for puberty to occur in beef heifers prior to 15 months of age. This will allow breeding to calve as two-year olds and will fit into the annual management cycle of the beef herd. With the influx of late-maturing continental breeds into herds and a shift toward the selection of larger framed heifers, the producer is unintentionally breeding and selecting for delayed puberty in replacements. Thus, it becomes increasingly difficult for the cow-calf producer to select heifers with desirable reproductive traits. If these trends continue, methods must be developed to decrease the age of puberty if replacement heifers are to calve as two-year olds.

Although age of puberty is controlled genetically, it can be altered by environmental and other factors such as plane of nutrition. Increasing the energy content of rations has been shown to increase the percentage of heifers exhibiting the first estrus prior to or during the first two weeks of the breeding season (Wiltbank et al., 1969; Short and Bellows, 1971; Bellows, 1966). A feed

additive, monensin, produced by the bacterium *Streptomyces cinnamonensis*, increases feed efficiency in beef cattle. In addition, monensin has been reported by researchers in Texas (Turner et al., 1977) to shorten the postpartum interval in Brahman cross cows, and subsequent studies (Moseley et al., 1977, and McCartor et al., 1979) showed that monensin in the rations of prepuberal Brahman cross heifers increased the proportion that reached puberty by a target date and decreased age and weight at puberty.

Another means to hasten the time of first estrus (Short et al., 1975) in prepuberal heifers is by treatment with a synthetic progestogen. Researchers at West Virginia University (Berardinelli, 1976) have induced puberty in approximately 70 percent of prepuberal heifers with daily injections of this hormone for seven days.

The objectives of this study were to determine: (1) if monensin could influence the efficiency of gain in prepuberal crossbred beef heifers; (2) if the addition of monensin to a ration would alter age and weight at puberty or ovarian development; (3) whether there would be any influence of monensin on puberty which was unrelated to the additional energy available to the heifers fed monensin; and (4) if the response to a short term treatment with progestogen to induce puberty would be influenced by monensin in the ration.

Materials and Methods

Two feeding trials were conducted at the West Virginia University Reymann Memorial Farms, Wardensville, West Virginia, beginning in January 1978 and 1979. In 1978, sixty-four crossbred prepuberal heifers of either Charolais X Hereford or Simmental X Charolais X Hereford X Red Angus breeding were divided into two groups based on initial weights: a lightweight group, which averaged 460 pounds, and a heavyweight group, which averaged 570 pounds. Heifers within each group were assigned to one of three dietary treatments. The treatments consisted of: (1) a control ration formulated according to their requirements to produce a desired rate of gain; (2) the control ration plus monensin incorporated at a rate of 26 g/ton of feed (provided approximately 200 mg/head/day of monensin); (3) a high energy ration formulated to provide approximately a 10 percent increase in rate of gain over the control ration. The high energy ration was utilized in this experiment to test if the reported influence of monensin on puberty was related to increased efficiency of energy utilization commonly observed when monensin is added to the diets of beef cattle. Based on a target weight of 675 pounds after 140 days on feed, the control and monensin rations were formulated (NRC, 1976) to obtain an approximate gain of 215 pounds (1.5 pounds/day) for the lightweight heifers and 115 pounds (.8 pounds/day) for the heavyweight heifers. Compositions of the rations are reported in Table 1.

The heifers were weighed at 24 to 30 day intervals, feed intake was accounted for, and plasma samples were collected via jugular puncture for determination of concentrations of glucose. Plasma glucose was measured in order to examine possible mechanisms by which monensin could decrease age of puberty. In order to indicate when they were approaching puberty, ovarian size (height, length and width in mm) and follicular development were determined by rectal palpation of 24 to 30 day intervals during the 140 day feeding period. Because the majority of heifers did not reach puberty at the end

Table 1

Ration compositions and ingredient consumption of heifers fed a control, a monensin treated, or a high energy ration in trials 1 and 2.

| | Lightweight Heifers | | | Heavyweight Heifers | | |
|---------------------------------|---------------------|----------------|----------------|---------------------|----------------|----------------|
| | Control | Monensin | High Energy | Control | Monensin | High Energy |
| Trial 1, % of diet | | | | | | |
| Ingredient ^a | | | | | | |
| Corn, ear, meal (%) | 44 | 44 | 50 | 2 | 2 | 5 |
| Mixed grass, hay (%) | 55.5 | 55.5 | 49.5 | 97.2 | 97.5 | 94.5 |
| Limestone (%) | .5 | .5 | .5 | - | - | - |
| Dicalcium phosphate (%) | - | - | - | .5 | .5 | .5 |
| Vitamin A ^b | + | + | + | + | + | + |
| Monensin, Na ^c | - | + | - | - | + | - |
| Trial 2, Intake/head/day | | | | | | |
| Ingredient | | | | | | |
| Pre-mix (lbs.) | 1 ^d | 1 ^c | 1 ^d | 1 ^d | 1 ^c | 1 ^d |
| Corn, ear, meal (lbs.) | 8.44 | 8.44 | 9.96 | 1.42 | 1.42 | 2.75 |
| Soybean meal (lbs.) | .28 | .28 | .31 | - | - | - |
| Mixed grass hay (lbs.) | 9.29 | 6.25 | 10.03 | 16.77 | 13.92 | 14.33 |

^aTrace mineralized salt offered free choice.

^b2200 IU/day.

^c200 mg/day.

^dPre-mix contained 95% ground ear meal, 5% Dicalcium phosphate, and 2200 IU Vit. A/lb.

^ePre-mix contained 95% ground ear meal, 5% Dicalcium phosphate, and 2200 IU Vit. A/lb. and 200 mg Monensin/lb.

of the 140-day feeding period, all animals were kept on their respective feeding regimens for an additional 45 days and examinations of the ovaries were conducted at weekly intervals by rectal palpation for the presence of a corpus luteum (CL) which would indicate if ovulation and thus puberty had occurred. In addition, throughout the entire trial heifers were observed daily for behavioral estrus. A heifer was determined to be puberal if she exhibited estrus and/or had a CL on one of her ovaries by the end of the trial. A jugular blood sample was obtained from each heifer for assay of progesterone when a palpable CL was detected in one ovary to confirm the accuracy of palpation. The volume (mm^3) of the ovaries was followed over the feeding period. This variable was determined by multiplying the estimated dimensions (length, width and height) as determined by rectal palpation.

In the second year, forty-nine crossbred prepuberal beef heifers of similar breeding as in year 1 were again divided into two groups based on their initial weights. Heifers were assigned randomly within sire groups to receive one of the three treatments described for the first year. However, in this trial a fixed portion of the concentrates was fed with hay free choice rather than the free choice feeding of a complete mixed diet. The amount of concentrate was adjusted monthly to achieve the appropriate weight gains. The compositions of the diets used in the second year also are reported in Table 1. Heifers were weighed and ovaries examined by rectal palpation as in trial 1. The heifers were palpated at biweekly intervals during the last forty-five days of the 154-day feeding period.

To determine whether monensin could alter the percentage of heifers attaining puberty in response to a hormonal induction treatment, an implant of a synthetic progestogen (norgestomet; 3.35 mg SAS-9; G. D. Searle and Co., IL) was placed subcutaneously in one ear of each heifer and remained in the animal for seven days. Implantation occurred immediately after the feeding period. Heifers were observed for estrus during the implant period, and eight days after the implant was removed the ovaries were examined by rectal palpation for the presence of a CL. Ovarian volume was determined as in the first year of the study. The percentage of heifers that attained puberty by the end of trial 1 and the percentage of heifers that exhibited estrus and ovulated in response to the norgestomet implant (trial 2) were analyzed statistically (Snedecor, 1973). Feed consumption, feed conversion and growth of the heifers were also analyzed in a similar manner.

Results

The performance on feed for the heifers fed the control, control plus monensin, and the high energy diets for both years is reported in Table 2. No differences in average daily gain were observed among the control, monensin, and high energy treatments. The heifers in trial 2 consumed significantly more feed than the heifers in trial 1. This difference can in part be attributed to feeding method. One can generally expect more waste when free choice hay is fed as opposed to a mixed ration. The feed efficiency or feed to gain ratio (Table 2) indicated that the heifers in trial 1 required significantly less feed per pound of gain than heifers in trial 2 and the performance of the lightweight heifers was significantly greater than that of heavyweight cattle. This was expected due to the higher proportion of corn fed the lightweight heifers. Summarizing the data

Table 2
Performance of heifers fed a control, a monensin
treated or a high energy ration.

| | Lightweight Heifers | | | Heavyweight Heifers | | |
|-----------------------------|---------------------|----------|-------------|---------------------|----------|-------------|
| | Control | Monensin | High Energy | Control | Monensin | High Energy |
| Trial 1 | | | | | | |
| No. of heifers | 10 | 11 | 11 | 10 | 11 | 11 |
| No. of days on test | 140 | 140 | 140 | 140 | 140 | 140 |
| Initial weight (lbs./head) | 462 | 454 | 459 | 578 | 570 | 568 |
| Final weight (lbs./head) | 604 | 695 | 679 | 739 | 726 | 734 |
| Average daily gain (lbs.) | 1.59 | 1.72 | 1.57 | 1.06 | 1.12 | 1.18 |
| Feed intake (lbs./head/day) | 14.00 | 14.28 | 13.03 | 14.62 | 14.34 | 15.22 |
| Feed/gain ratio | 8.8 | 8.3 | 8.3 | 13.8 | 12.8 | 12.9 |
| Trial 2 | | | | | | |
| No. of heifers | 8 | 8 | 9 | 8 | 8 | 9 |
| No. of days on test | 154 | 154 | 154 | 154 | 154 | 154 |
| Initial weight (lbs./head) | 438 | 436 | 437 | 553 | 555 | 555 |
| Final weight (lbs./head) | 695 | 686 | 715 | 716 | 713 | 708 |
| Average daily gain (lbs.) | 1.67 | 1.63 | 1.81 | 1.06 | 1.02 | .99 |
| Feed intake (lbs./day) | 19.01 | 15.97 | 21.30 | 19.19 | 16.34 | 18.08 |
| Feed/gain ratio | 11.4 | 9.8 | 11.8 | 18.1 | 16.0 | 18.3 |

over both years, there was a strong tendency for the monensin fed heifers to be more efficient (9.8%) than the controls.

The percentage of heifers reaching puberty averaged 66 by mid-June in year 1 (Table 3) and was not affected by either monensin or the high energy diets. Neither age at onset of puberty nor weight of those heifers that had reached puberty during trial 1 was affected by the diets. These values averaged 418 days and 768 pounds, respectively. The percentage of heifers that exhibited estrus and ovulation in response to the seven-day treatment with norgestomet in the second year was not affected by rations (Table 4). Overall, in the second year, 74 percent of the heifers exhibited estrus within five days after the removal of the norgestomet implant and 71 percent of these ovulated. Mean age at puberty (as defined by ovulation) was 411 days for the second year.

Regarding measurements which might indicate a tendency toward puberty, neither the size of follicles nor the percentage of animals with follicles which were greater than 10 mm differed due to rations, or age at which they were palpated; follicle size averaged 12 ± 2 mm over both trials.

Ovarian volume (mm^3) was not influenced by the rations fed for the first year. Heavyweight heifers had larger ovarian volumes than lightweight heifers and ovarian volume increased from the beginning to the end of the trial. The same trend was seen in the second year; however, no significant differences were observed. Plasma glucose was not influenced by the rations either within or over the monthly sampling periods.

Discussion

It has been reported by Raun et al. (1976) that monensin incorporated in the rations of feedlot cattle did not alter gain, decreased feed intake and resulted in more efficient utilization of feed. They suggested that monensin increased efficiency by making feed energy more readily available for the animal. The strong tendency for monensin to decrease the feed required for gain by about 10 percent in this study is in agreement with these findings.

Moseley et al. (1977) reported that incorporation of monensin into the rations of prepuberal beef heifers increased the percentage of heifers attaining puberty within 100 days after the end of the feeding period. In the present study, neither the percentage of heifers that reached puberty nor age and weight at puberty was influenced by ration. One major difference between their studies and this study is the breed type. The cattle in the studies of Moseley et al. (1977) and McCartor et al. (1979) were of Brahman breeding while the crossbred heifers in this study were of European breeding. Thus, there is a possibility that monensin may have an influence on the occurrence of puberty in Brahman cross heifers but not in heifers of European breeding.

McCartor et al. (1979) concluded that "any treatment which alters microbial fermentation in the rumen to produce greater proportions of the volatile fatty acid, propionate, will decrease age at puberty in beef heifers." In spite of the tendency toward increased feed efficiency, monensin may not have induced as much of a shift in ruminal production of propionate as it has been reported to do in other studies (Raun et al., 1976; McCartor et al., 1979); however, this has been the most consistent response induced by monensin and one would expect this to occur. Environmental conditions could be another reason for differences in the results from previous cited studies.

Table 3

The percentages of heifers attaining puberty and age and weight at puberty for heifers in trial 1.

| Item | Ration | | |
|------------------------|------------------------|-----------|-------------|
| | Control | Monensin | High Energy |
| % Puberal ^a | 60(12/20) ^b | 77(17/22) | 59(12/22) |
| Age at puberty, days | 414 ± 8 | 427 ± 10 | 413 ± 7 |
| Weight at puberty, kg | 346 ± 3 | 351 ± 4 | 350 ± 6 |

^aDetermined at mid-June; the end of trial 1.

^bNumber heifers attaining puberty/number heifers in group.

Table 4

The percentages of heifers on each ration that exhibited estrus and ovulation in response to a seven-day treatment of norgestomet in trial 2.

| Item | Ration | | |
|-----------------------|-----------------------|-----------|-------------|
| | Control | Monensin | High Energy |
| Exhibiting estrus (%) | 64(9/14) ^a | 81(13/16) | 76(13/17) |
| Ovulating (%) | 78(7/9) ^b | 54(7/13) | 85(11/13) |

^aIndicates number of heifers showing estrus per number of heifers treated with norgestomet.

^bIndicates number of heifers ovulating per number of heifers that showed estrus.

It has been suggested that increased ruminal production of propionate may result in increased blood glucose (McCartor et al. 1979). Glucose may be the major blood-borne energy source important in ovarian development of heifers. The monensin-containing ration did not increase blood glucose significantly in this study and there was no relationship between ovarian volume and glucose concentration. However, blood was examined for glucose concentration only once each 24 to 30 day period and time of sampling in relation to times of feed consumption varied in an uncontrolled manner.

A short-term treatment (seven days) with the synthetic progestogen, norgestomet, induced estrus and ovulation in a great percentage of the heifers within a five day period post-treatment. Rations did not influence the response of heifers to this treatment. A short or long term treatment with either progesterone or norgestomet has been reported to induce puberty in a large percentage of heifers near puberal weight and age (Berardinelli, 1976; Short et al., 1975). However, in their studies each heifer that exhibited estrus also ovulated while fewer heifers ovulated than had shown estrus in the second year

year of this study. The reason for this result is not known, but estrus without ovulation has been observed in prepuberal heifers which were pastured with puberal heifers in which estrus was synchronized with prostaglandin $F_{2\alpha}$ (Dailey et al., 1982). Thus, the psychological effect of several animals in estrus may be to induce estrus but not ovulation in heifers which have not yet reached puberty.

Changes in ovarian volume and follicular activity did not appear to be affected by ration fed, within weight group, in either year. In the first year of this study the heavyweight heifers had larger ovaries than lightweight heifers and ovaries increased in volume over time in both groups. Desjardins and Hafs (1969) reported that ovarian size increased progressively with age from birth to puberty in dairy heifers.

Although we have not observed any indication of an effect of monensin on age of puberty, we did observe that monensin decreased the amount of feed needed to produce an appropriate gain for replacement heifers.

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